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A REAPPRAISAL OF INCENTIVE CONTRACTING EXPERIENCE

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PREFACE

This study is part of RAND's continuing program of procurement research. It deals with one aspect of military procurement: the effectiveness of incentive contracts as a means of controlling defense procurement costs. This study identifies the various effects that these contracts may have on contract costs and on contractors' performance, and questions the validity of the cost savings commonly attributed to these contracts. Several possible strategies for improving their effectiveness are also discussed. Attention is given to the importance of the target cost in providing real and meaningful incentives for increased efficiency.

A previous study by the author, *Cost Incentives and Contract Outcomes: An Empirical Analysis*, RM-5120, September 1966, also examines the effects of cost incentives on contract costs. The present study, however, analyzes a larger sample of more recent data and extends the analysis to examine the response of individual contractors to incentive contracts. The study should be of interest to both military and civilian procurement officials who are concerned with the impact of incentive contracts on procurement costs.

SUMMARY

Incentive contracts are intended to motivate defense contractors to perform more efficiently and control costs more closely. By increasing the total profit as actual costs are reduced below a predetermined cost target, they encourage contractors to achieve cost underruns. Consequently, the principal advantage claimed for these contracts is that they make the financial incentives to reduce costs more effective.

This Memorandum examines the effectiveness of incentive contracts as a means for controlling defense procurement costs. The study considers the various effects that incentive contracts may have on both contractors' performance and contract costs, and presents empirical evidence suggesting that incentive contracts have not accomplished their intended goal of increased efficiency and lower procurement costs.

It is true that cost overruns have been far less frequent and less substantial under incentive contracts than under cost-reimbursable contracts. This has been interpreted by Defense Department officials as evidence that contractors perform more efficiently under incentive contracts. This interpretation may be misleading, however, because cost underruns can be achieved in several ways. The most obvious--and salutary--way is to reduce actual cost below the target cost, which is the effect desired by Defense Department officials. Another approach would be for the contractor to obtain a larger target cost--a target that exceeds the expected actual cost. This can also result in larger underruns and increased profits that are unrelated to any real cost savings. The contractor's ability to do this depends on the circumstances under which the target cost is determined. Nonetheless, since most weapon system production and support contracts are presently negotiated without benefit of price competition, the targets for these contracts may fail to provide any real incentives for cost reduction and efficiency.

Cost overruns and underruns are examined for a sample of Air Force contracts for major weapon systems. Although the results

illustrate the fact that underruns are more common with incentive contracts than cost-reimbursable contracts, the observed underruns do not seem to be related to the incentive features of these contracts. Cost underruns appear to be no larger for contracts with large sharing rates than for those with small ones. This suggests that incentive contracts have not had an important effect on contract costs or on contractor performance.

Since the magnitude of the cost underruns observed with incentive contracts seems to be unrelated to the incentive features of the contracts, these underruns cannot be attributed to increased efficiency and reduced costs. It is difficult to believe that contractors are generally more efficient and cost conscious under incentive-type contracts regardless of the differences in financial risk associated with the pricing provisions. It seems more likely that these observed underruns result from larger target costs--targets that exceed anticipated actual costs.

Present DOD weapon system procurement practices explain why it is possible for contractors to negotiate initial target costs on fixed price incentive contracts that exceed expected costs. Because it is common practice to awa[illegible]oduction and other follow-on contracts for weapon systems to the [illegible]ginal development contractor, effective price rivalry can exist only at the first stage of a weapon system acquisition program--the development stage. As a result, once the contractor has obtained the initial development contract, he is virtually assured of receiving all follow-on contracts without the threat of price rivalry from competing contractors. Target costs for these contracts must be negotiated without benefit of market price information, thereby providing the contractor with an opportunity to obtain targets that are sufficiently large to assure his achieving a cost underrun independently of any increased efficiency or actual cost reduction.

There is an important implication here for improving the effectiveness of incentive contracts. What is needed to make cost incentive contracts more effective are tighter target costs. In order to insure that incentive contracts motivate contractors toward increased efficiency and lower costs, it is essential that the target cost be a

realistic estimate of expected actual costs. Accordingly, future gains in incentive contracting are going to come through improved methods of determining target costs--increased use of competition and improved cost estimating techniques--rather than through more elaborate incentive sharing arrangements. Emphasis must be placed on obtaining better target cost information rather than on more complex incentive pricing arrangements.

Incentive contracts have several important advantages that should not be overlooked. Because of the upward shift in target costs, incentive contracts provide the Government with better program cost information than do cost-reimbursable contracts. Because target costs are more realistic for incentive contracts, they permit better financial planning and budgetary control while eliminating the large overruns characteristic of cost-reimbursable contracts. Moreover, incentive contracts may have made both the Government and defense contractors a little more cost-conscious than before. Contractors probably have different attitudes toward costs since the advent of incentive contracts than previously, and the Government may be taking the role of a cost-conscious buyer rather than of a benevolent sponsor. Consequently, these contracts may have resulted in cost savings. Unfortunately, these salutary effects cannot be measured and quantified.

CONTENTS

I. INTRODUCTION

Present defense procurement policy relies heavily on incentive pricing arrangements to motivate contractors to control costs and perform more efficiently--increased profits being the incentive.

There seems to be general agreement among Defense Department officials that incentive contracts have achieved their goal. Nonetheless, there are reasons for questioning the cost-saving effects claimed for these contracts. This study reexamines the effects of incentive contracts on contract costs and considers some prospects for improving their effectiveness.

TYPES OF CONTRACTS

Two basic types of pricing arrangements are used in defense contracting: fixed-price and cost-reimbursable contracts. Under cost-reimbursable contracts, the Government pays all legally allowable costs the contractor incurs during the life of the contract. Under fixed-price agreements, the contractor and the Government agree on a target cost; any discrepancy between the target cost and the actual cost may be borne entirely by the contractor or shared in some predetermined proportion with the Government.

The following are the major varieties of pricing arrangements:

Fixed-price contracts

- Firm-fixed-price (FFP)
- Fixed-price-incentive (FPI)
- Fixed-price-redeterminable (FPR)

Cost-reimbursable contracts

- Cost-plus-fixed-fee (CPFF)
- Cost-plus-incentive-fee (CPIF)

Most fixed-price contracts are presently either fixed-price-incentive (FPI) or firm-fixed-price (FFP).* FFP contracts presumably

*Fixed-price-redeterminable contracts (FPR) are no longer extensively used; moreover, it is erroneous to classify them as fixed-price contracts, since they provide for periodic price renegotiation during the life of the contract.

provide the maximum incentive for contractors to control cost, since the price remains fixed once the target has been established. FPI contracts, in contrast, contain a profit-sharing arrangement whereby the Government and contractor share any difference that occurs between the actual and target cost.

Only two varieties of cost-reimbursable contracts are used extensively. The cost-plus-fixed-fee (CPFF) contract reimburses the contractor for all allowable costs incurred in completing the contract. The contractor also receives a fixed fee that does not depend on his cost performance. Obviously, this form of pricing arrangement provides little, if any, incentive for contractors to control costs.

The cost-plus-incentive-fee contract (CPIF) is also a cost-reimbursable contract, since the Government bears all the allowable costs of contract performance; it is also an incentive contract, since it establishes both a target cost and a profit-sharing arrangement.

In March 1962, the Defense Department revised the Armed Services Procurement Regulations (ASPR) to encourage the use of incentive contracts. These revisions reflected a consensus of opinion within the Defense Department that the CPFF contracts then commonly used to purchase major weapon systems did not provide adequate incentive for contractors to control costs. These revisions established CPIF contracts as preferable for research and development effort and recommended the use of FFP or FPI contracts for production. Use of CPFF contracts is limited to situations involving considerable uncertainty, in which incentive-type contracts would be impractical.

These changes have had a tremendous impact on the defense industry and have resulted in a substantial increase in the use of FFP and other types of incentive contracts for defense procurement. As Table 1 indicates, the shift away from CPFF contracts has been striking. CPFF contracts accounted for more than one-third of total defense expenditures in 1960, but less than 10 percent in 1966. In the same period, CPIF contracts more than doubled, and FFP contracts nearly doubled.

Defense Department representatives believe incentive contracts are effective in controlling procurement costs. The principal

Table 1

PERCENTAGES OF TOTAL DEFENSE EXPENDITURES BY TYPE OF PRICING ARRANGEMENT

Contract Type	Fiscal Year						
	1960	1961	1962	1963	1964	1965	1966
Fixed Price							
FFP	31.4	31.5	38.0	41.5	46.3	52.8	57.5
FPI	13.6	11.2	12.0	15.8	18.5	16.6	15.9
Other[a]	12.4	15.2	10.8	7.6	6.4	7.1	5.8
Cost-Reimbursable							
CPFF	36.8	36.6	32.5	20.7	12.0	9.4	9.9
CPIF	3.2	3.2	4.1	11.7	14.1	11.2	8.3
Other[b]	2.6	2.3	2.6	2.7	2.7	2.9	2.6

SOURCE: Directorate for Statistical Services, OSD, Military Prime Contract Awards.

[a]Includes FPR contracts.

[b]Includes cost and cost-sharing contracts.

advantage claimed for these contracts is that they make the financial incentives to reduce costs more effective. By increasing the total profit as actual costs are reduced below the target, they encourage contractors to achieve cost underruns. They also place greater financial risk on the contractor since the Government no longer stands ready to completely absorb cost overruns.

It is true that cost overruns have been far less frequent and less substantial under incentive contracts than under CPFF contracts. Defense Department officials have interpreted this outcome as evidence that a contractor's performance under incentive contracts has been more efficient than under CPFF contracts. In fact, in evaluating the impact of incentive contracts on procurement costs, former Secretary McNamara stated that costs under incentive contracts are ten percent lower than they would have been under CPFF pricing arrangements.*

*See *Statement of Secretary of Defense Robert S. McNamara Before the House Armed Services Committee on the Fiscal Year 1966-1970 Defense Program and 1966 Defense Budget*, February 18, 1965, Senate Subcommittee on DOD Appropriations, p. 187.

Since underruns can be achieved in several ways, however, it may be precipitate to attribute underruns observed with incentive contracts to increased efficiency and cost reduction. The most obvious--and salutary--way for a contractor to achieve an underrun is to reduce actual cost below a reasonable target cost. This, of course, is the effect desired by Defense Department officials. A less demanding way is to obtain a larger target cost--a target that exceeds the expected actual cost. This will generate larger underruns and higher profits that are quite unrelated to any real cost savings.

In short, incentive contracts provide two different and discordant incentives for the contractor: to increase the target cost, and to reduce actual costs below the target. Consequently, it is not clear whether underruns commonly observed with incentive contracts result from increased efficiency or cost savings or from excessive target costs.

GOALS OF THE STUDY

This study reappraises the cost-saving effects claimed for incentive contracts and examines some prospects for increasing their effectiveness. The study has four major goals. The first is to provide some insight into how contractors may respond to profit incentives and to clarify the various effects that incentive contracts may have on cost outcomes. The second goal is to present some empirical evidence about the effects of these contracts, in light of recent Air Force experience. The third goal is to assess the merit of incentive contracts as a method for controlling procurement costs. The question here is whether these contracts can be expected to reduce costs significantly. The final goal is to discuss some alternatives for improving incentive contracts and to appraise the relative merits of each.

DATA USED IN THE STUDY

The sample used in this study contains 1007 contracts completed during fiscal years 1959 through 1966. The data consist solely of

Air Force contracts for major weapon systems and related equipment totaling nearly $15.7 billion. These data have been obtained from two sources. All large contracts (with amounts exceeding $1 million) administered by Air Force Systems Command and reported in the annual Reports of Contract Settlement have been included. Some additional Air Force contracts completed in fiscal year 1966 were obtained from the Directorate for Statistical Services, OSD. These contracts account for only $188 million of the total. Supplemental information describing other contract characteristics was obtained from DD Form 1500 and AFPI Form 85-A reports for the contracts included in the sample.

Some summary statistics describing various characteristics of the sample are contained in the following tables. Table 2 shows the total dollar amount and the average profit rate for each type of contract included in the sample. Both the initial target cost and the final cost (consisting of the initial target plus the costs of supplemental changes and modifications) are shown. The largest number of contracts contained in any group are CPFF contracts; the remainder are distributed among the various types of incentive pricing arrangements, the majority being FPI. The FPI contracts account for the largest dollar amount, however, and the CPIF and FPI contracts together include more than half of the total dollar amount represented in the sample.

An interesting feature of the data presented in Table 2 is the tendency for the average profit rate to enlarge as the cost incentives become more significant. The average negotiated profit rate increases from 5.9 percent for the CPFF contracts to 11.1 percent for the fixed-price contracts. These differentials seem to be consistent with present procurement policy as outlined in the ASPRs. According to these instructions, differences in financial risk should be considered in determining an appropriate profit rate. Since financial risk is generally assumed to be greater under FFP pricing arrangements than under CPFF, it seems likely that these differentials merely reflect the application of this policy by Air Force procurement officers.

Table 3 shows the distribution of dollar amounts for each of the

Table 2

CONTRACT AMOUNT AND AVERAGE NEGOTIATED PROFIT RATE BY TYPE OF CONTRACT

(In $ million)

Type of Contract	Adjusted Target Amount[a]	Final Contract Amount	Average Negotiated Profit Rate	No. of Contracts
FFP	209.4	209.4[b]	.111	59
FPR	1,288.6	1,281.3	.092	74
FPI	7,456.8	7,227.8	.089	319
CPIF	1,555.5	1,750.1	.054	37
CPFF	5,009.8	5,222.5	.059	518
Total	15,520.1	15,691.1	.076	1,007

[a]Initial contract amount plus supplemental changes.

[b]For FFP contracts, final contract amount is not reported reported by contractors. The amount shown here is the adjusted target cost.

Table 3

DISTRIBUTION OF FINAL CONTRACT AMOUNT BY TYPE OF CONTRACT AND YEAR OF COMPLETION

(In $ million)

Year	FFP[a]	FPR	FPI	CPIF	CPFF	Total
1959	30.9	1.6	--	--	--	32.5
1960	42.4	12.5	62.3	29.7	1,450.6	1,597.5
1961	24.3	148.1	2,632.9	1,015.1	869.8	4,690.2
1962	29.9	579.3	842.4	37.3	505.7	1,994.6
1963	46.8	151.8	1,520.1	285.9	748.0	2,752.6
1964	35.1	306.9	968.3	313.5	1,134.2	2,758.0
1965	--	76.9	1,132.1	49.9	425.5	1,684.4
1966	--	4.2	69.7	18.7	88.7	181.3
Total	209.4	1,281.3	7,227.8	1,750.1	5,225.5	15,691.1

[a]Initial contract amount plus supplemental changes.

years covered by the sample among the different types of contracts. The sample is unevenly distributed over the period, but provides adequate coverage for the years 1960-1965. The two end years, 1959 and 1966, contain a much smaller number of contracts and account for less than 2 percent of the total dollar amount.

Table 4 shows the distribution of total dollar amounts by sharing rate and also illustrates the relationship between the sharing rate and the average negotiated profit rate. Two-thirds of the total dollar amount is accounted for by contracts in two sharing rate groups; CPFF contracts with zero sharing rate and incentive contracts with sharing rate values between .20 and .29 each contain amounts exceeding $5 billion.

The average negotiated profit rate shown in Table 4 appears to be closely related to the sharing rate; as the sharing rate increases from zero (CPFF contracts) to unity (FFP contracts), the average negotiated profit rate also increases. Table 5 illustrates a similar effect. Here the distribution of contract amounts by both type of contract and average negotiated profit rate is shown, and it appears that average profit rates are generally larger for the fixed-price contracts than for the cost-reimbursable contracts. Moreover, the distributions of contract amounts appear to shift downward toward lower average profit rates as the financial constraints become less stringent. As explained before, these differentials probably result from present Defense Department profit policy and reflect a profit rate premium that compensates for differences in financial risk.

OUTLINE OF THE STUDY

This Memorandum is organized into five sections. Section II describes the structure of incentive pricing arrangements and discusses the different effects they may have on contractor response and contract cost outcomes. Section III utilizes the sample of Air Force contracts to compare differences that result in several measures of cost performance among various types of pricing arrangements. Consistent differences in cost outcomes that can be attributed to the individual contractor are the topic of Section IV. Here various

Table 4

DISTRIBUTION OF FINAL CONTRACT AMOUNT AND NEGOTIATED PROFIT RATE BY INCENTIVE SHARING RATE

Sharing Rate	Final Contract Amount[b]	Average Negotiated Profit Rate[c]	No. of Contracts
0	5,222.5	.059	518
.01-.09	1,773.1	.064	44
.10-.19	2,271.0	.079	144
.20-.29	5,519.3	.089	208
.30-.99	695.8	.092	34
1.0[a]	209.4	.111	59
Total	15,691.1	.076	1,007

[a]For FFP contracts, final cost is not reported by contractors. Amounts shown here are adjusted target costs.

[b]In $ million.

[c]Ratio of target fee to target cost.

Table 5

DISTRIBUTION OF FINAL CONTRACT AMOUNT BY TYPE OF CONTRACT AND AVERAGE PROFIT RATE

(In $ million)

Average Negotiated Profit Rate	FFP[a]	FPR	FPI	CPIF	CPFF	Total
Less than 4%	5.1	--	--	300.7	281.1	586.9
4.1-6.0	26.6	--	413.9	1,379.9	2,330.8	4,151.2
6.1-8.0	[illegible].0	250.8	1,185.8	65.1	2,422.1	3,952.8
8.1-10.0	56.1	801.4	4,851.1	4.4	186.4	5,899.9
10.1-12.0	71.5	229.1	772.3	--	2.1	1,075.0
Over 12%	21.1	--	4.2	--	--	25.3
Total	209.4	1,281.3	7,227.8	1,750.1	5,222.5	15,691.1

[a]For FFP contracts, final cost is not reported by contractors. Amounts shown here are adjusted target costs.

measures of cost performance are compared among a group of prime contractors for major Air Force weapon systems. Finally, Sec. V describes alternative methods for obtaining realistic target costs and discusses the difficulties and advantages of each.

II. EVALUATING THE IMPACT OF INCENTIVE CONTRACTS

This section examines the mechanics of incentive pricing arrangements and the different effects these contracts may have on contract costs. Some difficulties in measuring and evaluating their impact on costs are also discussed.

STRUCTURE OF INCENTIVE PRICING ARRANGEMENTS

Incentive contracts are supposed to motivate defense contractors to perform more efficiently and control costs more closely. This is accomplished through the incentive sharing provision, which allows contractors to retain part of any resulting cost underrun as increased profits. So long as these underruns represent realized cost reductions, incentive contracts accomplish their intended goal.

Total profits received by the contractor under an incentive contract consist of two components,

$$\Pi_T = \Pi_t + \alpha(C_t - C_f) \quad ,$$

where Π_T = total fee to contractor;
Π_t = profit on initial target amount;
C_t = target cost;
C_f = actual cost;
α = incentive sharing rate.

The first component is the profit amount based on the target cost. The second component is the profit sharing arrangement by which contractors retain part of any cost underrun that may result but must bear a portion of any cost overrun. The term inside the parentheses is an overrun when the actual cost exceeds the target, and an underrun when actual cost is less than the target.

Underruns increase profit and overruns reduce it, the contractor's share in either case being 100 α percent.

It is of course in the contractor's interest to increase the underrun and thereby increase his profit. One way to do so is to perform more efficiently and hold actual costs below the target value--

the effect desired by Defense Department officials. As discussed in Sec. I, however, overruns and underruns depend on both the actual cost and the target cost; therefore, another contractor strategy for avoiding overruns and increasing underruns is to secure as high a target cost as possible. The success of this strategy of course depends on the circumstances under which the target is determined. So long as targets are determined competitively, procurement officials need have little concern over their precise values. The market forces operating in a competitive environment tend to nullify the possibility of obtaining targets that are in some sense excessive.*

The difficulty is in determining appropriate target values for contracts negotiated in a noncompetitive environment. This problem is significant, because most weapon system production and support contracts are presently negotiated in the absence of any price competition. Moreover, many development contracts that are awarded competitively are awarded on the basis of technical or nonprice rivalry. Because target costs are commonly negotiated in these situations, contractors have much greater opportunity to increase them. If they succeed, the resultant targets may fail to provide any real incentives for cost reduction and efficiency.

Provided the Government has adequate information upon which to predict cost as well as the technical expertise required to make an independent cost estimate, a realistic target can be negotiated. Otherwise, an inflated target and a consequent underrun are the likely results. Such an underrun is unrelated to any real cost savings, merely reflecting the larger target cost.**

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*Although competition may eliminate excessive target costs, it may also result in the selection of a less efficient contractor. See J. J. McCall, *An Analysis of Military Procurement Policies*, The RAND Corporation, RM-4062-PR, November 1964.

**The supplemental changes and modifications that occur after the target has been established also provide an opportunity for the contractor to increase the target cost above the expected value. More precisely, the profit formula should be written

$$\Pi_T = \Pi_t + \Pi_S + \alpha(C_a - C_f) \quad ,$$

This point is illustrated in Fig. 1. Assume that actual cost, C_f, is a random variable with probability distribution $\phi(EC_f,\sigma^2)$, where EC_f is the expected actual cost and σ^2 is the variance. An overrun/underrun is defined as $Z = C_t - C_f$, where C_t is the target cost which is a constant. Now Z is a random variable also with probability distribution given by $\phi(EZ,\sigma^2)$, where EZ is the expected overrun/underrun and is equal to $(C_t - EC_f)$. In (a), the negotiated target cost is equal to the expected actual cost so that the expected overrun/underrun, EZ, is zero. That is, overruns and underruns are likely to occur with equal probability (at least for probability distributions symmetrical about EZ). In (b), however, the target cost is larger than the expected final cost so that $(C_t - EC_f) > 0$. In this case, underruns are more likely than overruns (again, for symmetrical distributions).

This discussion reveals the importance of the target cost in obtaining real and meaningful incentives. Obviously, too high a target gives the contractor little incentive to reduce costs. Too low a target allows him little chance of meeting it, and quality and performance may suffer in the bargain. It is apparent that the key to effective incentive contracts is obtaining targets that provide effective motivation for cost reduction and high performance.

RATIONALE FOR HIGHER TARGET COSTS

An important feature of incentive contracts is that they increase the risk of financial loss to the contractor by requiring him to bear

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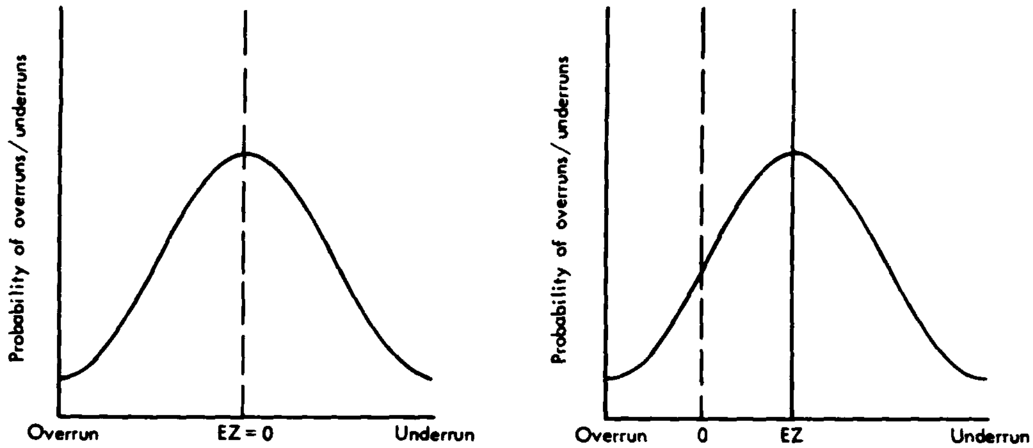
where Π_S = additional fee allowed on supplemental changes and modifications;

C_a = adjusted target cost, including the negotiated costs of supplemental changes and modifications

It is apparent that incentive pricing arrangements may also encourage contractors to propose frequent changes and modifications to the initial contract because these changes may result in additional profits, Π_S. Moreover, since the costs of changes and modifications must be negotiated, it also provides an opportunity for the contractor to increase the target cost, thereby improving the likelihood of an underrun. Through the remainder of this section, the term "target cost" will include the effect of supplemental changes and modifications; i.e., the adjusted target cost.



(a) Target cost equals expected cost

(b) Expected cost underrun

Fig. 1 -- Distribution of cost overruns/underruns

part of any cost overrun that may result. Assuming that contractors are generally averse to increased risk, profits on incentive contracts must be sufficient to offset the increased risk.

This is illustrated in Fig. 2. Curves U_1 and U_2 are typical indifference curves for a risk-averse contractor. These curves are upward-sloping, indicating that larger profits are required to compensate for increased financial risk, measured in terms of the sharing rate value. U_2 represents greater utility or satisfaction than U_1; given a contract with sharing rate α_1, for example, an increase in expected profit from Π_1 to Π_2 increases the contractor's utility from U_1 to U_2.

Consider a minimum-risk CPFF contract with expected profit equal to Π_1. Since the sharing rate value for CPFF contracts is zero, the level of utility corresponding to this contract is U_2. Now suppose the Government replaces it with an incentive contract having a sharing rate value equal to α_1. If the expected profit is unchanged, the contractor's utility decreases from U_2 to U_1. In order to make the incentive contract equally attractive to the contractor, expected

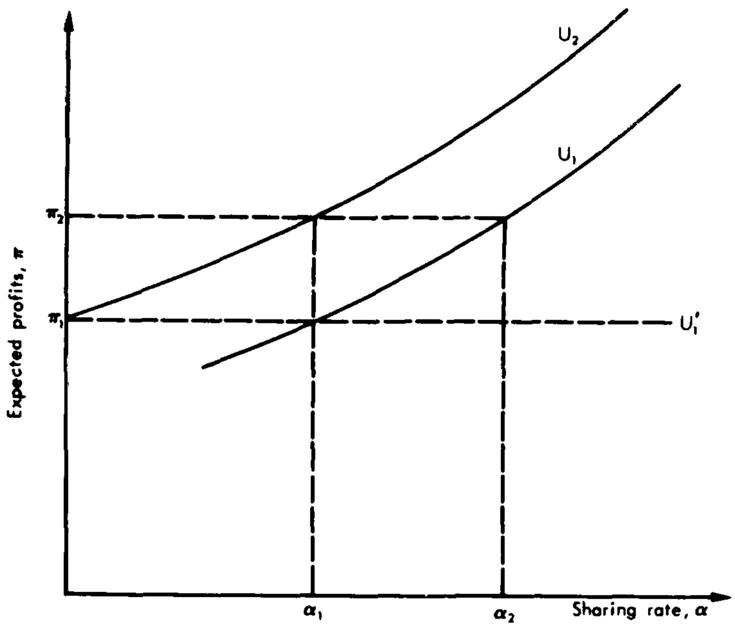


Fig. 2 -- Contractor's indifference curves

profit must be increased from Π_1 to Π_2. At this profit level the contractor will be indifferent between the two contracts. The profit differential, $\Pi_2 - \Pi_1$, is the risk premium necessary to compensate the contractor for the increased financial risk attached to the incentive contract.*

Compensation for the increased risk attached to incentive contracts can be provided in several ways. An obvious method would be for the Government to increase target profits by the amount of the required risk differential.** In practice, however, it may not be

*If the contractors were neutral toward increased risk, the utility function would appear as curve U_1'. In this situation contractors would be indifferent between minimum-risk CPFF contracts and maximum-risk FFP contracts, and no risk premium would be required.

**The DOD has recognized the need for larger profits on riskier incentive contracts with larger sharing rate values; the ASPR specifically provides for larger negotiated profit rates for these contracts. See ASPR 3-808.1 (6).

possible to increase profits sufficiently to offset the increased risk completely. If risk is large and the contractor extremely risk-averse, the required risk premium may be so large as to result in a rate of profit that is politically prohibitive. For example, profit rates of 40 percent or more might be required on some contracts; such rates would arouse Congressional interest and be difficult to explain.

Since it may not be possible to increase profits sufficiently to offset the increased financial risk inherent in incentive contracts, contractors may reduce the risk level by negotiating target costs high enough to provide a margin of safety against large overruns. This strategy is justified whenever profits are not sufficient to completely offset the greater risk.* In short, both larger profits and larger target costs may be required to compensate for the greater risk attached to incentive contracts. Unfortunately, the underruns that accompany these larger targets may be erroneously attributed to reduced costs and increased efficiency.

In general, the profit rate, sharing rate, and expected overrun/underrun are interrelated through their effects on the contractor's utility level. For example, increasing the profit rate would increase both the contractor's profit and his utility so long as the sharing rate and expected overrun/underrun remained constant. Similarly, increasing the expected underrun (by increasing the target cost) for a given profit rate and sharing rate also increases the contractor's profit and utility. An increase in the sharing rate, on the other hand, increases the financial risk and may decrease the contractor's utility level, especially if an overrun is likely. In this case it would be necessary to raise the profit rate or reduce the expected overrun in order to prevent the contractor's utility from declining.

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*Evidence indicates that larger target costs are negotiated as the sharing rate becomes larger. See John Cross, "A Reappraisal of Cost Incentives in Defense Contracting," P-282, Institute for Defense Analysis, 1966, and F. M. Scherer, *The Weapons Acquisition Process: Economic Incentives*, Harvard University Press, Boston, 1963. This has been explained as the compensation required to induce contractors to bear greater risk. Nonetheless, larger targets reduce the probability of overruns and increase the likelihood of increased profits.

Figure 3 shows a typical utility surface for a risk-averse contractor and illustrates the required tradeoffs among the sharing rate, profit rate, and expected overrun/underrun necessary to maintain a given level of contractor utility. All points on this surface represent possible combinations of these factors that result in a constant level of utility. Given a contract with expected overrun/underrun equal to zero, for example, line segment BAC indicates the tradeoff between the profit rate and the sharing rate necessary to hold the level of utility constant. As the sharing rate increases, larger profit rates are required to offset the increased risk resulting from the larger sharing rate values.

The effect of increased risk on both the required profit rate and the target cost can be easily determined from Fig. 3. Consider a minimum-risk CPFF contract with profit rate P' and zero expected overrun/underrun. This contract corresponds to point B on the contractor's utility surface. Now suppose the Government replaces this contract with an incentive agreement having a sharing rate value equal to α'. In order for the contractor to be indifferent between these two contracts, the profit rate must also be increased from P' to that level corresponding to point A on the contractor's utility surface. This larger rate of profit compensates the contractor for the increased risk introduced by the larger sharing rate value; the increased profit resulting from the larger rate of profit is the risk premium necessary to maintain a constant level of utility.* As the sharing rate value is further increased, the required profit rate also increases until, at point C (FFP contract with sharing rate value equal to unity), the required rate of profit is maximum.

Suppose, for example, that P' is the maximum rate of profit that is politically acceptable to the Government. From Fig. 3 it is clear that this rate of profit does not permit compensation for the riskier

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*Risk increases even though the expected overrun/underrun is zero, because the overrun/underrun is a random variable and there is some probability of very large overruns as well as underruns occurring. Consequently, the likelihood of cost overruns becomes more serious to the contractor as the sharing rate value becomes larger.

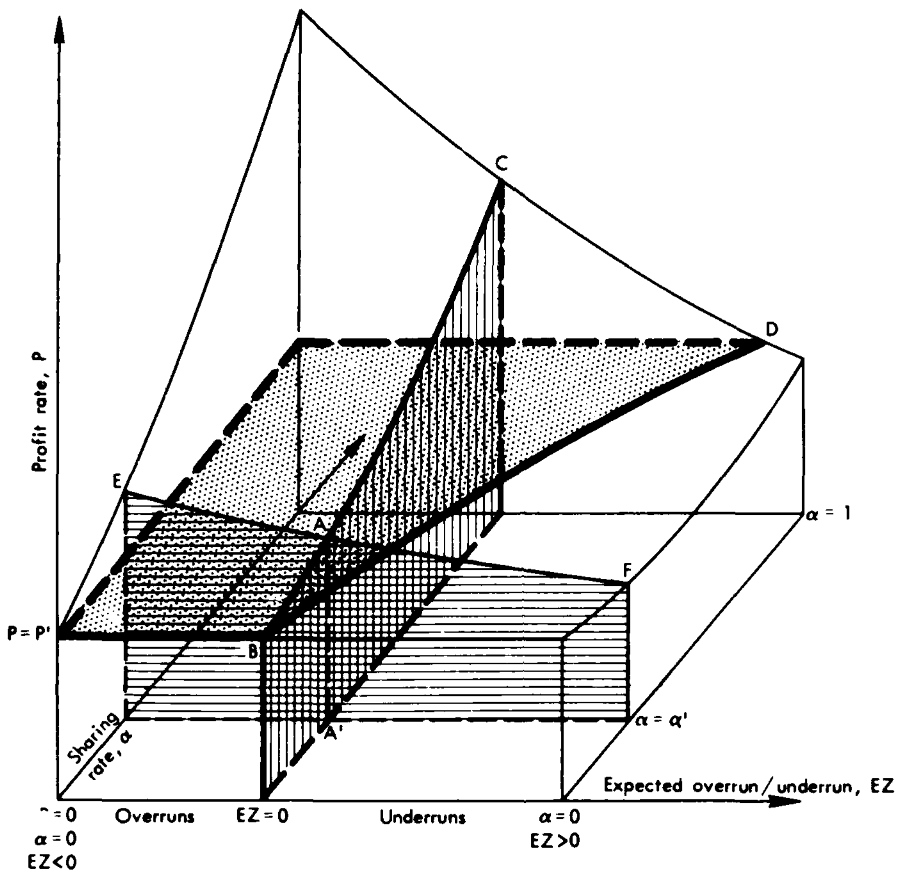

Fig. 3 -- Iso-utility surface

incentive contracts with larger sharing rate values. If contractors are forced to accept incentive pricing agreements at this rate of profit, however, their utility level will decline substantially. To prevent this, contractors will attempt to reduce the risk by lowering the probability of incurring an overrun (or by increasing the likelihood of an underrun). This can be done by negotiating larger target costs and by controlling actual costs more closely. In this example, line segment BD (formed by passing a plane parallel to the α - Z axis at P = P') indicates the increase in expected underrun

necessary to offset increases in the sharing rate and maintain a constant level of utility.*

In this example, underruns become more likely as the pricing arrangement is shifted from cost-reimbursable to incentive and as the sharing rate value becomes larger. This occurs because the contractor is motivated to reduce risk by increasing the likelihood of a cost underrun, and he can do this by increasing the target cost and reducing actual costs.

This discussion brings out the important point that incentive contracts really provide two different incentives; not only do they motivate contractors to reduce actual costs, but they also encourage them to overstate target cost estimates. Thus, it may be misguided to attribute the underruns observed with these contracts to reduced costs and improved performance, without more detailed analysis of the available evidence.

MEASURING THE EFFECTS OF INCENTIVE CONTRACTS ON COSTS

One of the limitations common to all empirical analyses of incentive contracts is that these two different incentive effects are not distinguishable. Consequently, it is never clear whether the underruns observed with incentive contracts result from increased efficiency and better cost control or from larger target costs secured by contractors to compensate for increased risk. To assess the true impact of incentive pricing arrangements on the cost of military procurement, it would be necessary to determine how target costs are affected by the incentive pricing provisions. The data required for

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*There is no reason why contractors should not utilize this strategy to achieve a level of utility beyond that corresponding to the CPFF pricing arrangement. Thus, expected profits may in some cases be increased sufficiently to make contractors much better off with incentive contracts than with cost-reimbursable contracts. The extent to which this can occur, of course, depends on the conditions under which the target cost is established, the uncertainty surrounding the anticipated actual cost, and the Government's cost-estimating ability.

the analysis, however, are not available.* Nonetheless, although it is impossible to separate directly the effects that incentive contracts have on target costs from their effects on actual costs, some inferences about how contractors respond to these contracts can be drawn by examining several measures of cost outcome for which data are available. These questions and the available evidence are discussed in the following sections.

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*One method for obtaining the necessary data would be to negotiate a set of combinations of alternative sharing rates, profit rates, and target costs for each contract. This would indicate the extent to which target costs are influenced by the pricing arrangement and would provide a basis for measuring the real effect of incentive contracts. See Ralph Miller, *A Method for Selecting Contract Cost Incentives*, The RAND Corporation, RM-5122-PR, March 1967.

III. EFFECT OF PRICING ARRANGEMENT ON CONTRACT COST OUTCOME

The preceding discussion described several ways in which contractors might respond to the increased risk inherent with incentive contracts, and indicated that the underruns common with incentive contracts need not result from increased efficiency or improved cost control.

This section compares contract cost outcomes for a sample of Air Force contracts. Two measures of cost outcome are considered; these are overruns/underruns, and costs of supplemental changes and modifications. Each measure is used for comparisons among different types of contracts, sharing arrangements, and other contract characteristics.

COST OVERRUNS/UNDERRUNS

Cost overrun/underrun is the difference between the final contract cost and the target cost (suitably adjusted to reflect costs of supplemental changes and modifications). Since incentive pricing arrangements sharpen the incentive for contractors to seek cost underruns, one would naturally expect to find that underruns are commoner with incentive contracts than with cost-reimbursable contracts. Table 6 compares the average cost overrun/underrun for several types of contracts included in the sample. An average overrun is observed for each group except the fixed-price-incentive contracts (FPI), illustrating the trend that is often interpreted by Defense Department officials as an indication of greater efficiency and cost reduction.*

Pricing Arrangement

Table 6 indicates that average overruns/underruns are different for each type of pricing arrangement. The significance of these differences can be tested statistically using analysis of variance to determine whether the observed overruns/underruns differ significantly among the four types of pricing arrangements.

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*Overrun/underrun is computed from $(C_f - C_a)/C_f$, so that underruns are negative while overruns are positive.

Table 6

AVERAGE OVERRUN/UNDERRUN BY TYPE OF CONTRACT[a]

Percentage of Final Cost

Type of Contract	Mean Overrun/Underrun
FPI	-3.18
FPR	1.74
CPIF	1.29
CPFF	1.90

[a]Unweighted averages of observed overruns/underruns for each type of pricing arrangement.

Table 7 presents the results. Data for 948 contracts are included in the analysis; the FFP contracts were excluded since no measure of overrun/underrun is available for these contracts. Note that the mean-square deviation of overruns/underruns is large between groups and small within groups. This indicates that there are significant differences in overrun/underruns among the four types of contracts but little variation within each group. An F-ratio value greater than 3.78 (at the .01 level of probability) is required in order to be confident that the observed differences among the four groups are anything but spurious. Since the computed value of the F-ratio is 8.7, the analysis indicates that these observed differences are statistically significant and are unlikely to have occurred by chance.*

*In order to determine whether the observed overrun/underruns are statistically different between groups, the within-group variation (i.e., variation of overruns/underruns in each group about the group mean) is compared with the between-group variation. If the variation within the groups is large while that between groups is small, differences between the groups may be insignificant. On the other hand, small within-group variation but large between-group variation suggests that the observed differences between groups may be significant. Analysis of variance computes the ratio of these variations (adjusted for degrees of freedom) and provides a formal method for testing the significance of the ratio.

Table 7

ANALYSIS OF VARIANCE FOR FOUR CONTRACT CLASSIFICATIONS

Variance	Sum of Squares	D.F.	Mean Squares	F Ratio
Between group	0.5354	3	0.1785	8.707
Within group	19.3255	944	0.0205	
Total	19.8609			

For FPR, the price is periodically renegotiated during the life of the contract. As a result, these contracts closely resemble cost-reimbursable contracts. This is also indicated to some extent in Table 6, where the average overrun observed for FPR contracts is nearly as large as that for CPFF.

For comparison, Table 8 repeats the analysis of variance with only two contract classifications: FPI contracts and all others. Here the FPR, CPFF, and CPIF contracts are combined into one group. The value of the F-ratio has increased substantially and is large enough to conclude that overruns/underruns observed for the FPI contracts are significantly different from those for the other contracts.

Table 8

ANALYSIS OF VARIANCE FOR TWO CONTRACT CLASSIFICATIONS: FPI AND ALL OTHERS

Variance	Sum of Squares	D.F.	Mean Squares	F Ratio
Between group	0.3826	1	0.3826	18.573
Within group	19.4783	946	0.0206	
Total	19.8609	947		$F_{.01} = 6.64$

Incentive Sharing Rate

These results indicate that cost outcomes (overruns/underruns) differ significantly between the FPI and other types of contracts. Another aspect of the incentive pricing arrangement, however, may also be related to the pattern of overruns/underruns observed for

these contracts; this is the value of the incentive sharing rate. Because both profits and financial risk depend on the sharing rate value, it seems reasonable to expect underruns to be greater for incentive contracts with larger sharing rate values.

Table 9 shows the average overrun/underrun and its standard deviation for incentive contracts classified according to sharing rate value. Note that an average overrun occurs for contracts in the first group--those with sharing rate values less than 10 percent--while the remaining three groups have average underruns. The reason is that most of the contracts in the first group are CPIF, while those in the remaining groups are FPI and FPR and, on the basis of the preceding results, overruns would be expected on average for the CPIF group. Although average underruns are indicated for the three groups with sharing rate values greater than 0.10, they appear to become progressively smaller as the sharing rate becomes larger. This is a curious result, since the opposite trend would be expected. The large standard deviations for each of these groups, however, indicate that there is considerable variation about the mean values.

Table 9

MEAN OVERRUN/UNDERRUN AND STANDARD DEVIATION

CPFF and FFP Contracts Excluded

Item	Sharing Rate Value			
	.01-.09	.10-.19	.20-.29	.30-.99
Mean[a]	1.45	-3.50	-2.32	-0.39
Standard deviation[a]	12.95	13.86	8.45	8.81
Number	43	144	156	87

[a]Measured as a percentage of final cost.

For a given type of incentive contract, observed underruns should be larger (or overruns smaller), on average, for contracts with larger sharing rates. The reason for this is that larger sharing rates presumably subject the contractor to greater risk of financial loss and,

consequently, provide stronger motivation to avoid overruns. At the same time, larger sharing rates also result in larger profits for each dollar of cost underrun achieved. As a result, there should be a tendency for underruns to be larger for contracts with larger sharing rate value.

Figure 4 illustrates one possible way of describing the predicted relationship between the sharing rate and cost overruns/underruns. If conventional beliefs about incentive fees are correct, low sharing rate values should be associated with cost overruns, while larger sharing rate values should be associated with cost underruns. This type of linear relationship can be described by an equation of the form:

$$(1) \qquad (C_f - C_a)/C_f = a_0 + a_1\alpha \quad ,$$

where α = incentive sharing rate;

C_f = final cost;

C_a = adjusted target cost (initial target plus changes and modifications); and

a_0, a_1 are undetermined coefficients.

One procedure for testing whether underruns are, in fact, larger for contracts with larger sharing rate values would be to compute the correlation between these two variables. A more interesting procedure is to estimate the values of the coefficients, a_0 and a_1, in Eq. (1) using simple regression analysis. This provides a measure of correlation along with several other useful statistics.

This has been done for the FPI, FPR, CPIF contracts; the results appear in Table 10. The value of the constant term, a_0 (shown in column 1), is the intercept illustrated in Fig. 4. These values provide an estimate of the average overrun/underrun that would result for the three types of contracts if the sharing rate were to approach zero. The estimated value for a_1, shown in column 2, is the slope of the curve illustrated in Fig. 4, and provides a measure of the effect of the sharing rate value on cost overruns/underruns. If underruns are larger for larger sharing rate values, the coefficient a_1 should

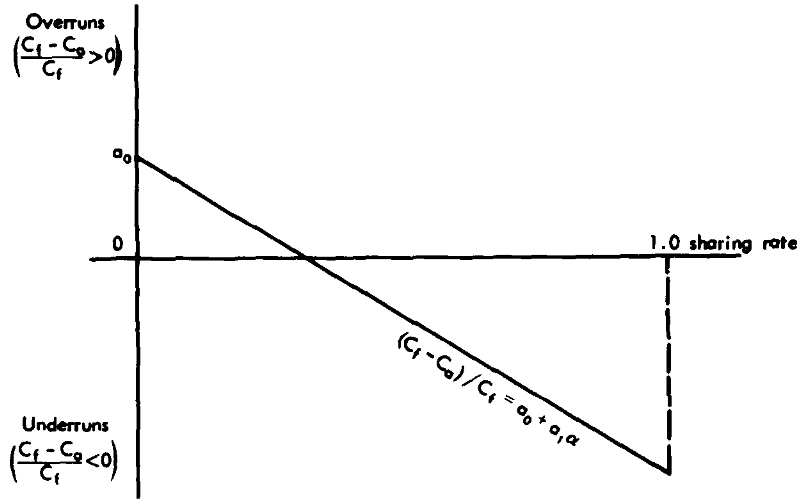

Fig. 4 -- Relationship between incentive sharing rate and overruns/underruns

be negative. A positive sign for this coefficient would imply smaller underruns for contracts with larger sharing rate values. The numbers appearing in the third column are the standard errors of the slope estimates and provide a measure of their reliability. The last column contains a measure of the correlation between observed overruns/underruns and the sharing rate value.

Table 10

ESTIMATED REGRESSION COEFFICIENTS

Cost Underrun/Overrun and Sharing Rate

Type of Contract	a_0	a_1	Standard Error of a_1	R^2
FPI	-0.100	0.3167	0.1066	0.0270
FPR	0.084	-0.7501	0.4441	0.0754
CPIF	0.050	-0.1903	0.1313	0.0283

Although two of the three estimated values for a_1 shown in Table 10 are negative, the coefficient for the FPI contracts is positive.

Moreover, when these three estimates are compared with their standard errors,* shown in column 3, the FPI coefficient is the only one that is statistically significant (at the .01 level of probability). This surprising result suggests that underruns are smaller, not larger, for FPI contracts with larger sharing rate values.**

Another measure of significance is provided by the R^2 values, shown in the last column. They provide a measure of the strength of the relationship between the sharing rate and cost overrun/underrun.*** In all cases the R^2 values are extremely low, indicating that the relationship between these variables is weak at best.

Contract Size

Another important factor that may affect this relationship is contract size. It seems reasonable to expect contractors to be more concerned with multimillion-dollar contracts than with million-dollar contracts because the financial consequences of cost overruns are much more serious. This possibility can be easily investigated by including a measure of contract size in Eq. (1). One obvious measure that could be used is contract cost. Including this in the relationship results in

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*The standard error of the regression coefficient provides a measure of variability of the estimated value. Large standard errors, for example, suggest that relatively little confidence should be attached to the accuracy of the estimate; small standard errors indicate that a relatively high degree of accuracy can be assigned to the estimate.

**This result holds only for the sample of Air Force contracts examined here. Nonetheless, it is based on a fairly large number of contracts and is difficult to explain. This question will be examined in more detail, however, in a later section discussing the observed pattern of supplemental changes.

***The value of R^2, called the coefficient of determination, is a measure of the proportion of total variance in overrun/underrun explained by the value of the sharing rate. For the FPI contracts, for example, 2.7 percent of the variation in overrun/underrun is explained by variations in the sharing rate value. The square root, R, is termed the correlation coefficient. A value for $R = \pm 1$ would indicate perfect (positive or negative) correlation, while a value of $R = 0$ indicates no correlation.

$$(2) \qquad (C_f - C_a)/C_f = a_0 + a_1\alpha + a_2C_f' \quad ,$$

where C_f' = log of final cost, C_f.*

Estimates of these coefficients for each type of contract appear in Table 11. None of the coefficients of size, a_2, are statistically significant at any reasonable level of confidence. Moreover, including size in the relationship has had little effect on the value of R^2 (compare Table 10). Consequently, size appears to have little effect on observed overruns/underruns for incentive contracts.

Table 11

ESTIMATED REGRESSION COEFFICIENTS

Cost Overrun/Underrun, Sharing Rate, and Contract Size

Type of Contract	a_0	a_1	Std. Error of a_1	a_2	Std. Error of a_2	R^2
FPI	-0.174	-0.311	0.107	0.019	0.016	0.032
FPR	0.128	-0.166	0.133	-0.021	0.032	0.093
CPIF	-0.019	-0.713	0.026	0.026	0.019	0.045

Summary

The preceding analysis suggests three major conclusions:

(1) Overruns/underruns for FPI contracts differ significantly from those observed with other types of contracts;

(2) Overruns/underruns seem to be unrelated to the value of the incentive sharing rate;

(3) Overruns/underruns are not associated with contract size, measured by total dollar amount.

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*Since costs vary widely (between $1 million and several hundred million), the logarithm of final cost has been used in place of the final cost. This acts as a scale factor to reduce large absolute differences in dollar amount while preserving relative differences.

These results indicate that although underruns are more common for FPI contracts than for other types, these underruns do not seem to be related to either the value of the sharing rate or to the size of the contract. Cost overruns/underruns appear to be no different for contracts with small sharing rate values than for those with large sharing rates, or for contracts differing substantially in total dollar amount. This suggests that these contracts have not had an important effect on contract cost outcomes or contractor performance.

Since the magnitude of the cost overruns/underruns observed with FPI contracts seems to be unrelated to either the value of the sharing rate or to contract size, it is difficult to attribute these underruns to increased efficiency and reduced costs. It is unlikely that contractors are equally efficient and cost-conscious for all FPI contracts regardless of differences in financial risk associated with the sharing rate and size of contract. It is more likely that these observed underruns result from larger target costs--targets that exceed anticipated actual costs.

There are essentially two ways in which contractors could insure that the adjusted target cost exceeds the expected cost. One would be to negotiate larger target costs to the extent possible during contract negotiation. This, of course, would depend on the circumstances under which the contract was awarded--that is, the degree of monopoly power enjoyed by the contractor. Another possibility, once the initial target had been negotiated, would be to introduce numerous and costly changes and modifications in the original specifications. This strategy would also improve the likelihood of achieving cost underruns. Although there is at present no way for determining the extent to which initial target costs may be inflated, the costs of supplemental changes and modifications are known. Consequently, the effects of different contract characteristics on the magnitude of these costs can be explored in some detail.

SUPPLEMENTAL CHANGES AND MODIFICATIONS

Contractors may be able to increase the likelihood of achieving a cost underrun by introducing frequent supplemental changes and

modifications. This strategy provides the opportunity to adjust the target cost upward and would appear particularly attractive whenever the target cost is close to the contractor's anticipated actual cost. Table 12 summarizes average costs of supplemental changes, measured as a percentage of final cost, for four major types of contracts.* Supplemental changes appear to be considerably larger for the cost-reimbursable contracts than for the fixed-price contracts. This may reflect the greater technical uncertainty inherent in those projects typically included under CPFF coverage.

Table 12

SUMMARY STATISTICS: SUPPLEMENTAL CHANGES AND MODIFICATIONS

Percentage of Final Cost

Type of Contract	Mean
FPI	4.17
FPR	7.97
CPIF	77.15
CPFF	60.08

Pricing Arrangements

It seems apparent from Table 12 that supplemental changes for the cost-reimbursable contracts are considerably larger than for the fixed-price contracts. Nonetheless, the standard deviations for each type of contract are also large in relation to the mean values. Consequently, it is possible that these observed differences could have occurred by chance.

In order to test this hypothesis, analysis of variance has been applied to the two types of pricing arrangements: cost-reimbursable and fixed price. The results are summarized in Table 13. The large value for the F ratio indicates that the observed differences cannot

*Only 745 of the 948 contracts are included here; 203 CPFF contracts were omitted because of missing initial target cost data.

Table 13

ANALYSIS OF VARIANCE: TYPE OF PRICING ARRANGEMENT

Variance	Sum of Squares	D.F.	Mean Squares	F
Between group	3.463	1	3.463	28.010
Within group	91.856	743	0.124	
Total	95.319	744		$F_{.01} = 6.66$

be attributed to chance (at the .01 level of confidence) but result, instead, from some basic differences between these two types of pricing arrangements.

As discussed above, one possible explanation for this difference could be differences in the competitive environment under which these contracts are awarded. The current practice of automatically awarding follow-on production contracts to the initial developer eliminates the competitive threat from all *subsequent contracts* and, through this "lock-in," places the contractor in a monopolistic position. Underbidding on initial development contracts is an obvious consequence of this procurement strategy.

Incentive Sharing Arrangements

It is also possible that costs of supplemental changes and modifications may be related to the sharing rate value. Contractors may request changes more frequently for contracts with large sharing rate values in order to compensate for the increased financial risk. One possible relationship that can be explored is given in Eq. (3):

$$(3) \qquad (C_a - C_i)/C_f = a_1 + a_1\alpha \quad ,$$

where C_a = adjusted target cost;

C_i = initial target cost;

C_f = final cost;

α = incentive sharing rate; and

a_0, a_1 are the intercept and slope coefficients, respectively.

This relationship has been estimated for the FPI, FPR, and CPIF contracts; the results appear in Table 14. For all three types of contracts the R^2 values are extremely low, indicating little relationship between the value of the incentive sharing rate and the magnitude of the supplemental changes. Less than one and one-half percent of the observed variations in supplemental changes can be explained by differences in the sharing rate for the FPI contracts; the results are even less impressive for the other types of contracts.

The values of the coefficients of the sharing rate, a_1, indicate the effect that changes in the sharing rate may be expected to have on the magnitude of the supplemental changes. Comparing these values with their standard errors indicates that the coefficient for the FPI contracts is statistically significant (at the .05 level of probability) while the estimated values for the other contracts are not. Given the value of this coefficient, however, a 10-percent increase in the sharing rate should increase the amount of supplemental changes only one and one-half percent. Consequently, although some relationship between the sharing rate and the magnitude of the supplemental changes appears to exist, other factors must account for the major differences among supplemental changes observed for FPI contracts.

Table 14

ESTIMATED REGRESSION COEFFICIENTS: SUPPLEMENTAL CHANGES AND INCENTIVE SHARING RATE VALUES

Type of Contract	a_0	a_1	Standard Error of a_1	R^2
FPI	.0442	.1491	.0692	.0138
FPR	.0408	-.1289	.1440	.0111
CPIF	.1511	.4395	.7659	.0095

Contract Size

It is possible that supplemental changes may be related to contract size. For example, supplemental changes (measured as a percentage of final cost) may be larger for multimillion-dollar contracts than for smaller contracts because of greater technical uncertainty

and risk inherent i · r w apon system contracts. Including an additional variable to int for relative differences in size results in

$$(C_a - C_i)/C_f = a_0 + a_1\alpha + a_2C_f' \quad , \tag{4}$$

where C_f' = log of final cost.

Estimates for these coefficients appear in Table 15 for each type of incentive contract. As before, the coefficient of the sharing rate, a_1, is statistically significant for FPI contracts but not for the other types. However, the coefficients for contract size, a_2,

Table 15

ESTIMATED REGRESSION COEFFICIENTS:
EFFECT OF CONTRACT SIZE

Type of Contract	a_0	a_1	Std. Error of a_1	a_2	Std. Error of a_2	R^2
FPI	-.1981	.1571	.761	.0616	.0175	.0587
FPR	.0639	-.1261	.1465	-.0062	.0213	.0138
CPIF	-.2182	.3238	.7565	.1016	.0674	.0884

are statistically significant for both the FPI and CPIF contracts (but not for the FPR contracts). Including contract size has increased the R^2 values slightly for these two types of contracts, indicating that size does have some effect on the magnitude of supplemental changes. Nonetheless, the proportion of total variation in supplemental changes explained by contract size and sharing rate value is extremely small. Consequently, other factors must be found to explain major differences in the magnitude of supplemental changes.

Summary

These results suggest two major conclusions:

(1) Supplemental changes are substantially larger for cost-reimbursable contracts (CPIF, CPFF) than for the fixed-price contracts (FPI, FPR);

(2) For the incentive contracts, the magnitude of supplemental changes is not closely related to the value of the incentive sharing rate or to contract size.

These results indicate that the costs of supplemental changes are not affected by the increased risk inherent in incentive contracts with profit sharing arrangements. Supplemental changes are larger for cost-reimbursable contracts than for fixed-price contracts, but seem to be unrelated to the incentive sharing rate.

COST UNDERRUNS AND SUPPLEMENTAL CHANGES

It is possible that underruns and supplemental changes are directly related so that larger supplemental changes result in larger underruns. One way of investigating this possibility is to estimate the relationship given in Eq. (5):

$$(5) \qquad (C_f - C_a)/C_f = a_0 + a_1(C_a - C_i)/C_f \quad ,$$

where C_f = final contract amount;

C_a = adjusted target cost (initial target plus supplemental changes);

C_i = initial negotiated target cost;

and a_0, a_1 are unknown coefficients to be estimated. If underruns are greater for contracts with larger supplemental changes, a_1 should be negative and statistically significant.[1]

Table 16 presents the estimated values for the coefficients along with their standard errors and coefficients of determination for three types of incentive contracts. In all cases the values for R^2 are extremely low, indicating that underruns and supplemental changes are not closely related. Thus it appears that contractors do not utilize supplemental changes to inflate target costs and increase the magnitude of cost underruns.

Table 16

ESTIMATED REGRESSION COEFFICIENTS: UNDERRUNS AND SUPPLEMENTAL CHANGES

Type of Contract	a_0	a_1	Standard Error of a_1	R^2
FPI	-.0274	.01002	.03093	.0003
FPR	.0085	-.17541	.08393	.0571
CPIF	-.0164	-.00862	.04072	.0012

CONCLUSIONS

These results indicate that although underruns are more common with fixed-price-incentive contracts, these underruns are not related to the pricing provisions of the contract. Consequently, these underruns should not be attributed to increased efficiency or reduced costs. It is difficult to believe that contractors are generally more efficient and cost-conscious under FPI contracts regardless of differences in financial risk associated with the incentive sharing. It seems more likely that these observed underruns result primarily from target costs that exceed anticipated actual costs.

Contractors can increase the adjusted target cost above the anticipated actual cost by either of two possible strategies. One would be to negotiate larger initial target costs--targets that are sufficiently greater than expected actual costs to provide a margin of safety against possible cost overruns. The extent to which this may be possible, of course, depends on the degree of price rivalry as well as on the Government's ability to predict actual costs accurately. The other alternative would be to introduce costly supplemental changes in order to provide a basis for negotiating a larger adjusted target cost beyond the actual costs of the changes, thereby increasing the likelihood of an underrun.

The results obtained here, however, indicate that supplemental changes do not explain the underruns observed with incentive contracts. Consequently, the most likely explanation is that target costs on FPI contracts are probably significantly larger than anticipated actual costs.

Given this environment, it is easy to understand why contractors may understate the cost estimates submitted during the development phase. This strategy improves the likelihood of obtaining not only the initial development contract but also an enviable monopolistic position with respect to all subsequent production contracts. Moreover, since most development contracts are cost-reimbursable, there are no effective constraints or penalties to discourage underbidding. As a result, both large cost overruns and large supplemental changes should be expected for development contracts (CPIF and CPFF), while underruns should be typical for the production contracts (FPI and FPR). These underruns merely indicate negotiated target costs that exceed the contractor's expected costs.

There is an important implication here for improving the effectiveness of incentive contracting. In order to assure that incentive contracts accomplish their goal of improved efficiency and reduced costs, it is essential that the target cost be a realistic estimate of expected actual costs. Otherwise, these contracts can never provide effective motivation to reduce costs or perform more efficiently. Thus, the most significant improvements in incentive contracting techniques are not going to be realized through more elaborate pricing arrangements or incentive structures, but through improved methods for obtaining target costs--targets that more closely reflect the contractor's anticipated costs.

How can better target cost information be obtained? Two alternatives are worth considering in detail. The first, and perhaps currently most popular, is based on more accurate methods for estimating weapon system costs. The other alternative relies on increased competition to generate market price information. Both alternatives are discussed in Sec. V.

IV. COMPARISON OF COST OVERRUNS/UNDERRUNS AMONG CONTRACTORS

The results of Sec. III indicate that both cost overruns/underruns and supplemental changes differ markedly between cost-reimbursable and fixed-price contracts. Thus, it appears that contractors react differently to these two types of pricing arrangements. There may also be significant differences in cost performance among individual contractors, however. For example, some contractors may achieve cost underruns consistently, while overruns may be typical for others. This section compares cost overruns/underruns for major Air Force contracts with 15 large contractors.

SUMMARY STATISTICS

Table 17 summarizes the average overrun/underrun for those contracts exceeding $1 million held by 15 large Air Force contractors. As before, underruns are more common for the fixed-price contracts (FPI and FPR) than for the cost-reimbursable contracts (CPIF and CPFF).

Table 17

COMPARISON OF AVERAGE OVERRUNS/UNDERRUNS: FIFTEEN LARGE AIR FORCE CONTRACTORS

	Cost-Reimbursable Contracts		Fixed-Price Contracts	
Contractor	Average Overrun	No.	Average Overrun	No.
1	.0463	10	.0323	13
2	-.0436	20	-.0746	21
3	.0671	7	.0010	10
4	-.0044	21	-.0106	13
5	.0142	29	-.0327	18
6	.0012	51	-.0507	4
7	-.0412	11	.0107	72
8	-.0080	50	.0598	6
9	.0050	13	-.0097	15
10	-.0889	28	-.0219	29
11	-.0958	21	-.0726	6
12	.1267	4	-.0220	31
13	.0325	40	-.0950	11
	.0631	10	-.1595	6
15	.0086	10	-.0421	32

Nonetheless, several contractors have average underruns for both cost-reimbursable and fixed-price contracts, while others have average overruns for both types. This suggests that there may be some important differences among individual contractors' responses to these contracts.

DIFFERENCES AMONG CONTRACTORS

Analysis of variance can be utilized to determine whether these average overruns/underruns differ significantly between contractors. Tables 18 and 19 present the results for cost-reimbursable and fixed-price contracts, respectively. For the cost-reimbursable contracts, the differences in average overruns/underruns between contractors are not statistically significant. That is, overruns/underruns are not noticeably different among cost-reimbursable contracts for any of the contractors included in the sample. For the fixed-price incentive contracts, however, the value of the F ratio is statistically significant (at the .01 level of probability), indicating that there are important differences in observed overruns/underruns among contractors. Thus, for fixed-price contracts, some contractors apparently experience larger cost underruns, on average, than do others.

Table 18

ANALYSIS OF VARIANCE: COST-REIMBURSABLE CONTRACTS, FIFTEEN LARGE AIR FORCE CONTRACTORS

Variance	Sum of Squares	D.F.	Mean Squares	F
Between group	.5597	14	.0400	1.596
Within group	7.7668	310	.0251	
Total	8.3265	324		$F_{.05} = 1.72$

There are two possible explanations for these differences. It may be that some contractors are more responsive to observed profit incentives than others. That is, some contractors may perform more efficiently or apply greater pressure for larger target costs on contracts with larger sharing rates than other contractors. On the

Table 19

ANALYSIS OF VARIANCE: FIXED-PRICE CONTRACTS, FIFTEEN LARGE AIR FORCE CONTRACTORS

Variance	Sum of Squares	D.F.	Mean Squares	F
Between group	.4915	14	.0351	4.228
Within group	2.2596	272	.0083	
Total	2.7511	286		$F_{.01} = 1.73$

other hand, some contractors may be generally more efficient than others regardless of the pricing arrangement, may be more aggressive in negotiating larger target costs, or may enjoy certain competitive advantages that increase the likelihood of achieving cost underruns. For example, both absence of market price information and lack of meaningful competition improve the contractors' ability to obtain larger target costs and larger cost underruns.

If the first explanation--differences in *contractors' responses* to incentive pricing arrangements--is correct, observed underruns for each contractor should be larger for contracts with stronger profit incentives. Alternatively, if the observed differences in cost underruns result principally from negotiation strategy, market position, and overall efficiency, the magnitude of the underruns should be relatively constant among a contractor's incentive contracts.

One approach for determining which of these alternatives better explains the observed differences in underruns among contractors is to estimate the relationship between the pricing arrangement and cost overrun/underrun for each contractor. This relationship is described in Eq. (6).

$$(6) \qquad (C_f - C_a)/C_f = \gamma_j + b_j\alpha \qquad j = 1, \ldots, 15 \quad ,$$

where γ_j = average overrun/underrun for the j^{th} contractor;
b_j = effect of the incentive sharing rate on the j^{th} contractor.

In this formulation the overrun/underrun for each contract,

measured as a percentage of final cost, is expressed as the sum of two components; the first is the average overrun/underrun for the individual contractor, γ_j, while the second, b_j, reflects the effect of the pricing arrangement on the contractor. If the estimated values for the b_j's differ significantly among contractors while the values for the γ_j's remain relatively constant, then variations in observed underruns should be attributed to differences in individual contractors' responses to the profit incentives. If, on the other hand, the b_j's are relatively constant but the γ_j's vary noticeably among contractors, then variations in observed overruns/underruns should be attributed to individual contractor-specific characteristics such as the contractor's ability to estimate target costs, his competitive advantage, negotiation strategy, and overall differences in efficiency.

Estimates of these coefficients appear in Table 20. Note the differences between the average overruns/underruns shown in Table 17 and the estimated values shown here. These differences occur because the sharing rate accounts for a portion of the average overruns/underruns shown in Table 17. The estimated values for both the γ_j and b_j coefficients differ substantially among contractors. The significance of these variations can be determined by testing the following hypotheses;

$$H_1: \ \gamma_i - \gamma_j = 0 \quad \text{for all } i, j;$$

$$H_2: \ b_i = b_j = 0 \quad \text{for all } i, j.$$

Hypothesis 1 asserts that there are no significant differences in average overruns/underruns among contractors, while Hypothesis 2 asserts that the effect of the pricing arrangement on overruns/underruns is negligible for each contractor.

These hypotheses can also be tested using analysis of variance. The ratios of the explained mean square deviation to the unexplained mean square deviation for each set of variables are computed in Table 21. Since the critical value of the F ratio (at the .01 level) is 1.79, H_1 can be rejected while H_2 cannot. This means that the b_j's are not statistically different from zero or, in other words, that the incentive pricing arrangement has had little effect on the cost

Table 20

ESTIMATED COEFFICIENTS: FIXED-PRICE CONTRACTS

Contractor	γ_j	b_j	Contractor	γ_j	b_j
1	.0836	.0081	9	-.0179	.0046
2	-.1541	-.0159	10	-.0175	.0059
3	.0313	.0055	11	-.0279	-.0099
4	.0234	-.0029	12	-.0712	.0033
5	-.0117	-.0056	13	-.0945	.0153
6	-.0285	.0041	14	-.1242	.0080
7	.0294	.0011	15	-.0518	-.0158
8	-.0933	-.0122			

performance of these contractors. Thus the overruns/underruns observed for these contractors must be explained by other factors.

The γ_j's, on the other hand, are statistically significant, indicating that there are important differences in average overruns/underruns among these contractors. Some contractors consistently achieve larger underruns than others and, since these underruns cannot be explained by differences in incentive pricing arrangements, they must be related to other characteristics peculiar to each contractor.

Table 21

ANALYSIS OF VARIANCE: FIXED-PRICE CONTRACTS

Item	Sum of Squares	D.F.	Mean Squares	F
Pricing arrangement, b_j	.0754	15	.0050	.549
Contractor effect, γ_j	.3347	15	.0223	2.451
Unexplained residual	2.3411	256	.0091	
Total variation	2.7512	286		

CONCLUSIONS

This analysis suggests three major conclusions:

(1) For cost-reimbursable contracts, cost overruns/underruns

cannot be distinguished among the fifteen contractors included in the sample;

(2) For the fixed-price contracts, cost overruns/underruns differ significantly among contractors;

(3) These differences in observed underruns are unrelated to the incentive feature of these contracts but reflect, instead, other contractor-related factors.

These results indicate that although average overruns/underruns for fixed-price contracts differ significantly among contractors, these differences cannot be explained by variations in contract pricing arrangements. There appears to be no relationship between the incentive arrangement and the observed cost overruns/underruns for any of the contractors examined. Consequently, it seems unlikely that the larger underruns observed for some contractors result from utilizing contracts with incentive pricing arrangements.

It may be that those contractors with the largest underruns produce different types of products involving less undertainty than do those experiencing smaller underruns (or larger overruns). This explanation seems unlikely, however, since all 15 contractors examined were large, well diversified, and produced similar products. It seems more likely that these observed underruns result from differences in other contractor-related factors--factors that include competitive advantage, cost-estimating ability, negotiation skill and general managerial capability. Some contractors may consistently be able to obtain larger target costs than others, for example, thereby increasing the likelihood of obtaining underruns.

These results are not consistent with the hypothesis that stronger incentives lead to greater efficiency and lower costs. Larger observed underruns seem to be generally unrelated to the profit incentive features of fixed-price contracts. The evidence indicates that these observed underruns originate, instead, from target costs that exceed the contractor's anticipated actual cost. Given present weapon system procurement practices, it is easy to see how this is likely to occur. So long as subsequent production and follow-on contracts are awarded to the initial development contractor without effective price rivalry, there can be no guarantee that the negotiated target cost is sufficiently

close to the contractor's anticipated actual cost to provide a meaningful incentive for greater efficiency and reduced costs.

In short, incentive contracts cannot be expected to provide the motivation for which they were intended without some means for establishing realistic target costs.

V. PROSPECTS FOR IMPROVING INCENTIVE CONTRACTS

This study has examined the use of incentive contracts as a means for motivating defense contractors toward greater efficiency and reducing defense procurement costs. The evidence presented in the preceding sections, however, suggests that incentive contracts have not accomplished this goal. While cost underruns do seem to occur more frequently with incentive contracts, the magnitudes of the observed underruns appear unrelated to the incentive provisions. Thus, it seems likely that many of the underruns observed with incentive contracts have resulted primarily from target costs that exceed contractors' anticipated costs.

INCREASING THE EFFECTIVENESS OF INCENTIVE CONTRACTS

The key to effective incentive contracts is the target cost. In order to provide real and meaningful incentives, it is essential that the target be a realistic estimate of the contractor's expected cost. So long as prices are determined competitively, there can be little chance of awarding contracts with targets that significantly exceed contractors' anticipated costs. The market forces operating in a competitive environment will tend to nullify the possibility of obtaining excessive targets.

In the present defense procurement environment, however, target costs for most incentive contracts awarded for major weapon systems are negotiated without benefit of competition. The reason for this is that the DOD typically awards weapon system production and follow-on contracts to the original development contractor without competition from alternative suppliers. As a result, effective price rivalry can exist only at the first stage of the program--the development stage. Once the contractor obtains the initial development contract, he is assured of receiving subsequent production and follow-on contracts without threat of competition from other potential producers. Because the targets for these contracts must be negotiated without market price information, it is extremely difficult for the Government to determine whether the resulting target cost is reasonably close to

the contractor's expected cost. Thus contractors may be able to negotiate targets sufficiently above their anticipated costs to substantially increase the likelihood of achieving a cost underrun and the resulting increased profits.* Consequently, an obvious and familiar suggestion for determining realistic prices for major weapon systems and also for providing targets that result in real efficiency incentives would be to increase the extent of competition in weapon system procurement.

What are the prospects for increased competition? A number of alternative strategies have been proposed in recent years, several of which appear promising.** These techniques range from the total package procurement concept*** at one extreme to a strategy of complete separation at the other.**** Although the DOD has not made extensive use of any of the available strategies, they could provide an effective and relatively inexpensive method for increasing the competitive pressure in weapon system procurement.

The importance of utilizing competition to determine target costs in weapon system procurements cannot be overemphasized. Nonetheless, there will be many situations in which price rivalry cannot be

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*Procurement officials have recognized the difficulty with this method of awarding contracts for major weapon systems. For example, in an address before the Institute on Management of Pre-Development Phase of Government Contracts (September, 1965), Deputy Assistant Secretary of Defense (Procurement) John M. Molloy stated: "While most production and support contracts are either fixed price or contain incentives, these arrangements are negotiated for the most part in a noncompetitive environment and may or may not have resulted in the establishment of targets which provide a contractor real and meaningful incentives. These circumstances provide the strongest incentive to increase the competitive aspects of systems procurement."

**See G. R. Hall and R. E. Johnson, *Competition in the Procurement of Military Hard Goods*, The RAND Corporation, P-3796, March 1968, for a discussion of the merits and limitations of various methods for introducing increased competition.

***Office of the Assistant Secretary of the Air Force (I&L), "Total Package Procurement Concept," May 10, 1966.

****Under the separation strategy, development, production, and follow-on contracts are separated and awarded competitively, and may or may not all go to the same contractor.

effectively used--situations in which technical uncertainties are large, the number of potential suppliers limited, etc. It seems likely, moreover, that this group will continue to include a major portion of all weapon system procurements. In these cases the DOD must rely upon its cost-estimating capability to provide reasonable target costs. Consequently, another prospect for increasing the effectiveness of incentive contracts is through improved cost analysis and estimating techniques.

Recognizing the need for improved cost information, the DOD has given considerable attention to improving its cost-estimating capability. Much effort has been devoted to developing a comprehensive data base consisting of cost information from previous weapon system acquisitions. The DOD has also improved its cost-estimating methodology and its cost-reporting systems,* and some procurement officials now appear to believe that cost-estimating techniques can be so refined as to become an effective substitute for price competition in establishing realistic target costs.**

Cost estimation can be an important tool in obtaining improved cost information for weapon system procurement. Nonetheless, it cannot provide cost estimates that are in any sense equivalent to the costs that would result through competition among potential suppliers. There are two reasons for this. First, cost estimation relies extensively on past experience to provide estimates of the costs of proposed weapon systems. Consequently, cost estimates obtained in this

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*The Truth-in-Negotiations Act (PL 87-653) is intended to insure the reliability and accuracy of contractor-furnished cost information.

**The rationale for this is made clear in the following remarks presented by Harold Asher, formerly Deputy for Cost Analysis to the Assistant Secretary of Defense (Systems Analysis) in an address to the Operations Research Society of America, October 16, 1966: "... the assumption is made that DOD is able to estimate the cost of a new weapon system at least as accurately as any single contractor. The reasonableness of this assumption should be apparent. DOD's cost experience is based on all the weapons produced for DOD while a single company has only its own past programs as an experience base. The assumption is predicated on the effort we are now making to exploit this greater amount of data and experience."

manner can be no better than the underlying data upon which they are based. Clearly, if the costs for the previous weapon system procurements were not obtained competitively, the resulting estimates cannot be regarded as being comparable to competitively determined costs. Unfortunately, the majority of the weapon system contracts contained in the DOD's data bank were not awarded competitively.

Even if they had been, the resulting cost estimates would not be equivalent to competitively determined costs. The reason for this is that cost estimation utilizes data from a number of contracts with different contractors to derive an estimate of the cost of a proposed weapon system. Because some contractors are more efficient than others, this estimated cost is in reality an average cost--that is, an estimate of the cost that would result for a firm of average efficiency. Since the most efficient and, hence, lowest-cost contractors would typically receive those contracts awarded competitively, competitively determined costs would be generally lower than estimated costs. Nonetheless, estimated target costs do provide some positive efficiency incentives for the less efficient contractors and, as a result, are useful in situations where competition is not possible.

In short, cost estimation does provide a useful tool in situations where competition cannot be utilized effectively. The important point is that these estimated costs may be considerably larger than competitively determined costs and may not provide the strongest efficiency incentives. Since competition is unlikely to be feasible in a large majority of the weapon system procurements, however, any improvements that can be made in cost-estimating methodology are probably well worthwhile.

Another strategy for improving the effectiveness of incentive contracting is to utilize these contracts more selectively. In the past, incentive contracts have been applied in numerous cases in which the technical uncertainties were so large that they precluded any meaningful target cost determination. It is important to recognize these situations and either rely on some other form of pricing arrangement or postpone negotiating the target cost until the uncertainty has been resolved. Better project definition prior to negotiating

the incentive structure could contribute much toward improving the effectiveness of these contracts.

IMPLICATIONS

The statistical analysis presented here suggests that some of the advantages usually attributed to incentive contracts may be illusory. It is commonly believed that incentive contracts provide substantial entrepreneurial motivation for increased efficiency and tighter cost control. This belief is one of the stronger justifications for the current extensive use of cost-incentive contracts. The evidence presented here, however, implies that the incentive effect on contractors' costs and efficiency may be weaker than is customarily believed. Rather, the evidence suggests that the cost underruns commonly observed for Air Force incentive contracts are the result of a general upward shift in target costs rather than improved cost control.

Nothing can be said here about the total cost of a weapon system under an incentive contract as compared to that under a cost-reimbursable contract. There is no way to analyze how the choice of contract type affects the overall cost of a weapon system; the results obtained here relate only to differences between actual and target costs. The main point demonstrated here is that incentive contracts probably are not saving the Government much money through increased efficiency and better cost control. Consequently, the merits of incentive contracts will have to be judged on other grounds.

Incentive contracts have several important advantages that should not be overlooked. Because of the upward shift in target costs, incentive contracts provide the Government with better program cost information than do cost-reimbursable contracts. Because target costs are more realistic for incentive contracts, they permit better financial planning and budgetary control while eliminating the large overruns characteristic of cost-reimbursable contracts. Moreover, incentive contracts may have made both the Government and defense contractors a little more cost-conscious than before. Contractors probably have different attitudes toward costs since the advent of incentive contracts than previously, and the Government may be taking

the role of a cost-conscious buyer rather than of a benevolent sponsor. Consequently, these contracts may have resulted in cost savings. Unfortunately, these salutary effects cannot be measured and quantified.

There is an important implication here for improving the effectiveness of incentive contracts. What is needed to make cost-incentive contracts work effectively are tighter target costs. In order to insure that incentive contracts motivate contractors toward increased efficiency and lower costs, it is essential that the target cost be a realistic estimate of expected actual costs. Thus, future gains in incentive contracting are going to come through improved methods of determining target costs--increased use of competition and improved cost-estimating techniques--rather than through more elaborate incentive sharing arrangements. Emphasis must be placed on obtaining better target cost information rather than on higher sharing rates and more complex incentive structures.

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10. ABSTRACT

An examination of the cost-saving effects claimed for incentive contracts and of the prospects for increasing their effectiveness. Statistical analysis of 1007 Air Force contracts for major weapon systems, completed during FY 1959-1966 and totaling nearly $15.7 billion, indicates that while incentive contracts may motivate contractors to reduce actual costs, they also encourage them to overstate target costs. The evidence indicates that the underruns commonly associated with incentive contracts are not related to the incentive features of the contract or to improved cost control and efficiency on the part of the contractor. While incentive contracts may make both the Government and contractor more cost conscious, other means--increased use of competition and improved governmental cost-estimating techniques--must be employed to reduce target cost and obtain an overall reduction in the cost of major weapon systems.

11. KEY WORDS

Budgeting
Cost analysis
Military contracts
Prices
Weapon systems